

The paradox of a wet (high H₂O) and dry (low H₂O/Ce) mantle: High water concentrations in mantle garnet pyroxenites from Hawaii.

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Water dissolved as trace amounts in anhydrous minerals has a large influence on the melting behavior and physical properties of the mantle. The water concentration of the oceanic mantle is inferred from the analyses of MORB and OIB [1], but there is little data from actual mantle samples. Moreover, enriched mineralogies (pyroxenites, eclogites) are thought as important sources of heterogeneity in the mantle, but their water concentrations and their effect on the water budget and cycling in the mantle are virtually unknown. Here, we analyzed by FTIR water in garnet clinopyroxenite xenoliths from Salt Lake Crater, Oahu, Hawaii. These pyroxenites are high-pressure (>20kb) crystal fractionates from alkalic melts. The clinopyroxenes (cpx) have 260 to 576 ppm wt H₂O, with the least differentiated samples (Mg#>0.8) in the 400-500 ppm range.

Orthopyroxene (opx) contain 117-265 ppm H₂O, about half of that of cpx, consistent with other natural sample studies, but lower than cpx/opx equilibrium from experimental data. The pyroxenite cpx and opx H₂O concentrations are at the high-end of on-and off-craton peridotite xenolith concentrations [2] and those of Hawaiian spinel peridotites. In contrast, garnet has extremely low water contents (<5ppm H₂O). There is no correlation between H₂O in cpx and lithophile element concentrations. Phlogopite is present in some samples, and its modal abundance shows a positive correlation in Mg# with cpx, implying equilibrium. However, there is no correlation between H₂O concentrations and or the presence of phlogopite. These data imply that cpx and opx may be at water saturation, far lower than experimental data suggest.

Reconstructed bulk rock pyroxenite H₂O ranges from 200-460 ppm (average 331 +/- 75 ppm), 2 to 8 times higher than H₂O estimates for the MORB source (50-200 ppm), but in the range of E-MORB, OIB and the source of rejuvenated Hawaiian magmas [1,3]. The average bulk rock pyroxenite H₂O/Ce is 69 +/-35, lower than estimates of the MORB source (~150) or FOZO, C (200-250) mantle component, but consistent with “dry” EM sources (<100) [1]. These data suggest that a metasomatized, refertilized oceanic lithosphere that contains pyroxenitic veins (e.g. the lower part of an oceanic plate, where ascending melts can become trapped and crystallize), will have both higher water concentrations and low H₂O/Ce, and may contribute to EM-type OIB sources, like that of Samoa basalts [5]. Therefore, a low H₂O/Ce mantle source may not necessarily be “dry”.

[1] Dixon et al., 2002, *Nature* 420, 385-389. [2] Peslier, (2010) *JVGR* **197**, 239-258. [3] Dixon *et al.*, (1997) *JP* **38**, 911-939. [4] O’Leary et al. (2010) *EPSL* 297, 111–120. [5] Workman et al., (2006) *EPSL* 241, 932 – 951.